OHL 134

Thurlby PL Series

Power Supplies

SERVICE MANUAL

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Introduction

The PL series of power supplies are fully variable series regulated units incorporating separate digital meters for voltage and current. Separate voltage and current control circuits enable them to operate in constant voltage or constant current mode from 0 to 31 volts at 0 to 1.1 amps or 2.2 amps.

In addition to the AC input switch, there is a DC output switch. When this switch is 'off', in addition to disconnecting the +ve output, the current meter is caused to read the value of the current control setting. The current meter decimal points are used to indicate the mode as follows:-

Decimal points off	- output switch 'on', constant voltage operation, meter reading output current.
Decimal points on	- output switch 'off', meter reading current limit setting.
Decimal points flashing	- output switch 'on', constant current operation, meter reading output current.

A damping switch is incorporated on the current meter input. This provides a long time constant which averages out rapidly fluctuating load currents.

The input to the voltage control circuit and voltage meter are brought out to front panel terminals labelled 'sense'. These are normally connected to the output terminals by shorting bars, but can be connected to the output at the load via separate leads in order to eliminate inaccuracies caused by lead resistances.

Quad-Mode Dual versions incorporate push button switches enabling Isolated, Parallel, Series, or Series Tracking operations to be selected.

General and Safety

This manual has been prepared to aid the experienced engineer in the maintenance and repair of Thurlby PL Series power supplies. It should be used in conjunction with the owners Manual.

Recalibration or repair should only be attempted by skilled personnel in conjunction with high quality test equipment. If the user is in any doubt as to his competence to carry out the work, the supply should be returned to Thurlby Electronics Ltd. or their agents overseas for the work to be carried out.

The equipment is AC∿ line powered and must only be dismantled by personnel conversant with the hazards of working on line powered equipment. When working on the unit with the cover removed, the protective earth conductor must be connected to line ground, and the sleeving and shrouds covering AC∿ line live and neutral conductors must be in place.

The equipment must be disconnected from line power whilst being dismantled, and power should only be applied when essential for carrying out testing and adjustment.

Dismantling the Equipment

The cover is removed by removing the two screws through the handle, and the two screws on each side. On Dual units a further four screws must be removed from the top.

The front panel may be disconnected from the chassis by removing the two front feet and the self-tapping screw directly between them. This allows the front panel to be laid downwards giving improved access to the rear of the P.C.B. All preset adjustments are accessible through the P.C.B.

Should it be necessary to gain access to the front of the P.C.B., this should be done by removing the four screws out of the front of the front panel. This will allow the P.C.B., heatsink bracket, and displays to be removed as a complete assembly.

SPECIFICATION

Input Voltage:	.110, 120, 220, 240V AC ± 10% at 48-63Hz.
Output:	0-31 Volts nominal 0-1.1A nominal (PL310), 0-2.2A (PL320)
Output Terminations:	4mm terminals on 19mm (¾") spacing DC=== output switch.
Sensing:	Remote via 4mm terminals or Direct via shorting links (provided).
Line Stability:	<0.01% of maximum output for 10% line chan
Load Regulation:	<0.01% of maximum output for 50% load chan
Ripple and Noise:	<1mV typically.
Output Impedance:	<5mΩ typically at 1kHz.
Temperature Coefficient:	<0.01%/^{0}C typically.
Transient Response:	<20μsecs typically to <50mV of setting for 100% load change.
Constant Current Output Impedance:	50KΩ typically with voltage limit at maxim
Voltage Controls:	Continuously variable by coarse and fine controls, setability 0.005 Volts.
Current Limit:	Continuously variable from 0 to 110% of maximum current rating. Automatic indicati of constant current operation.
Mode Selection: (Dual Unit only)	Isolated, True parallel, Series or Series Tracking via front panel switches.
Meters:	Dual 3¾ digit (4000 count) with 12.5mm (½ LED's. Reading rate 4 per second.
Meter Resolution:	Voltage 0.01 Volts over entire range. Current 0.001 Amps over entire range.
Meter Accuracy: 20^{0}C - 25^{0}C	Voltage 0.1% reading ± 0.05% full scale. Current 0.3% reading ± 0.1% full scale.
Current Meter Damping:	Normally 20msec switchable to 2 secs for averaging of rapidly varying loads.

/continued..

SPECIFICATION (Contd...)

Operating Temperature Range:	0^0 -45^0 C.
Dimensions:	235mm x 175mm x 155mm (9.25 x 6.9 x 6.15") single 235mm x 175mm x 345mm (9.25 x 6.9 x 13.6") dual
Electrical Safety:	Designed and manufactured to comply with IEC348.

CIRCUIT DESCRIPTION

Block Diagram

The transformer incorporates two secondary windings, one which produces the main supply powering the output, and another which produces an auxilliary supply powering the control and metering circuits.

The series regulator is placed in the positive output of the main supply, but because of the way in which the control and metering circuits operated, it is convenient to label the output of the series regulator as 0 Volts, and to regard the negative side of the main supply as being the controlled output voltage (-V out).

The auxilliary supply provides stabilised symmetrical voltage outputs V+ and V- with the common point connected to the +ve output via the output switch and the +ve sense.

The series regulator is controlled by the 'voltage control circuit' until the output current flowing reaches the current limit setting, upon which the 'current control circuit' takes over. This circuit operates by monitoring the voltage across the current sense resistor R8. The current meter monitors either the voltage across R8 or the voltage from the current set control VR1, depending upon the state of the 'meter select circuit' which is controlled by S2.

The Main Supply

This consists of a full bridge rectifier D5 to D8 feeding the reservoir capacitor C6. The full load secondary winding voltage is 36V rms and R2 and C5 form a damping network. With nominal mains input, the voltage across C6 with no load current is about 55 Volts, falling to about 40 Volts at full load with 5 Volts pk-pk ripple.

The Series Regulator

This consists of NPN Darlington Pass Transistors Q2 and Q3 driven by emitter follower Q1 which is itself driven by resistor R15. The stage is controlled by pulling the base of Q1 low via either D14 or D15.

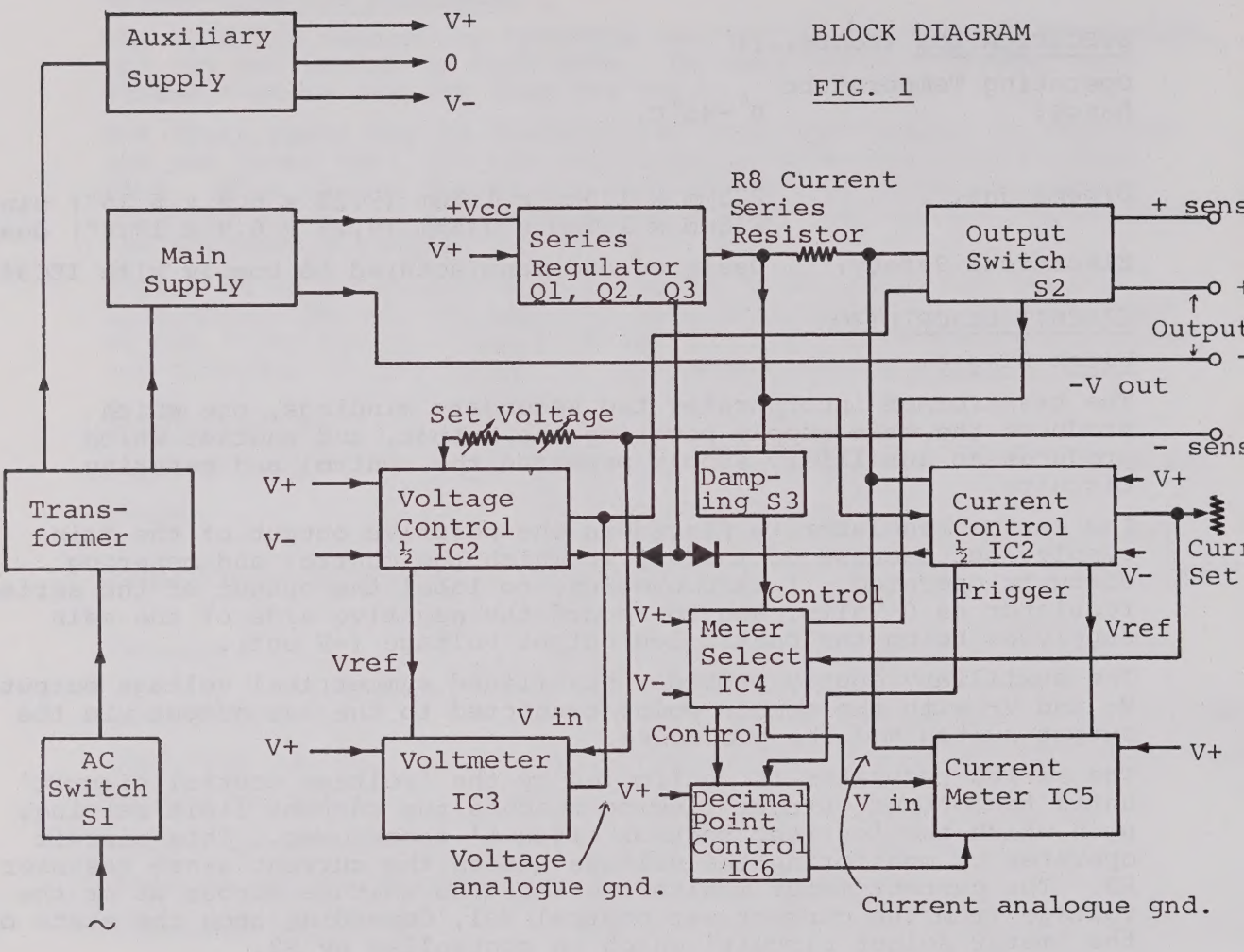
In 2 Amp versions, Q3 is replaced by a parallel combination of four transistors with current sharing resistors.

The Auxilliary Supply

This consists of twin full wave rectified supplies from a 21 Volt centre tapped winding, D1 and D2 feeding C1 for the positive supply, and D3 and D4 feeding C2 for the negative. The positive supply V+ is a high current supply (approx. 400mA) which is series regulated by the 3 terminal regulator IC1. This is a 5 Volt regulator, but its output is raised by diode D9 to be +5.7 Volts ± 0.2 Volts. The negative supply V- is a low current supply (approx, 5mA) shunt regulated by zener diode Z1 to be -5.6 Volts ± 0.4 Volts.

BLOCK DIAGRAM

FIG. 1



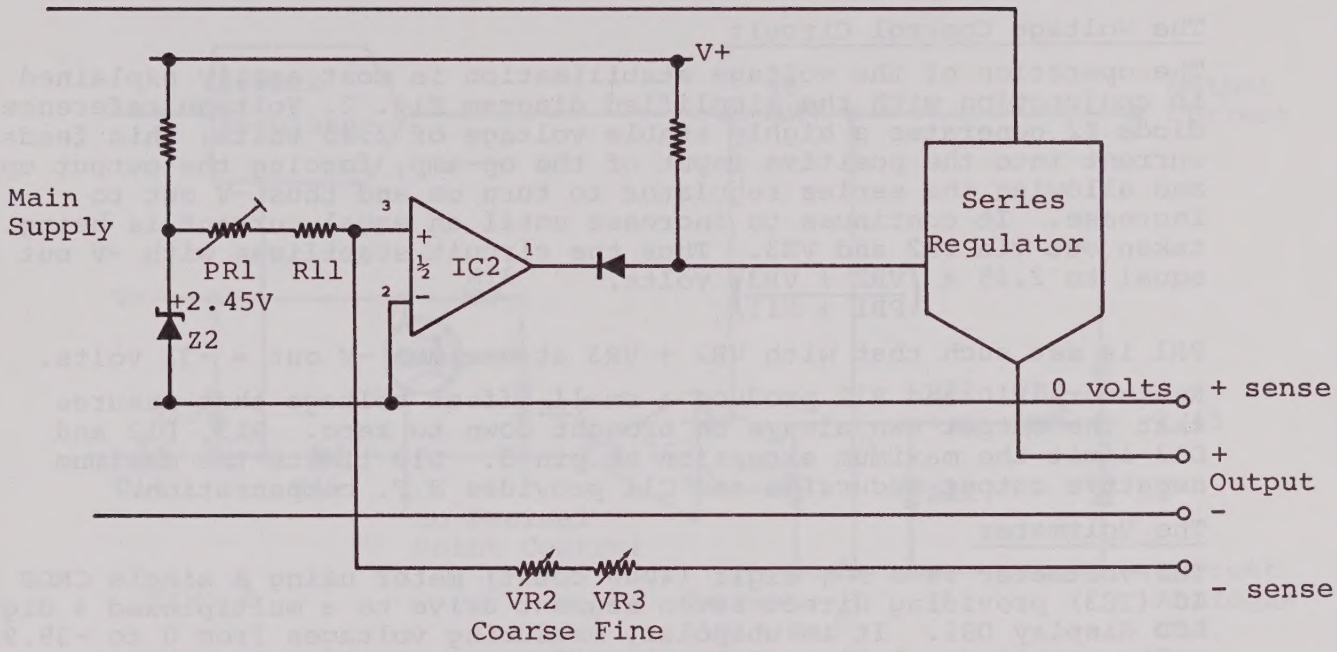

V+
Main
Supply
PR1
R11
+2.45V
Z2
IC2
Series
Regulator
0 volts
+ sense
+
Output
-
- sense
VR2
VR3
Coarse
Fine
Voltage Set

FIG. 2

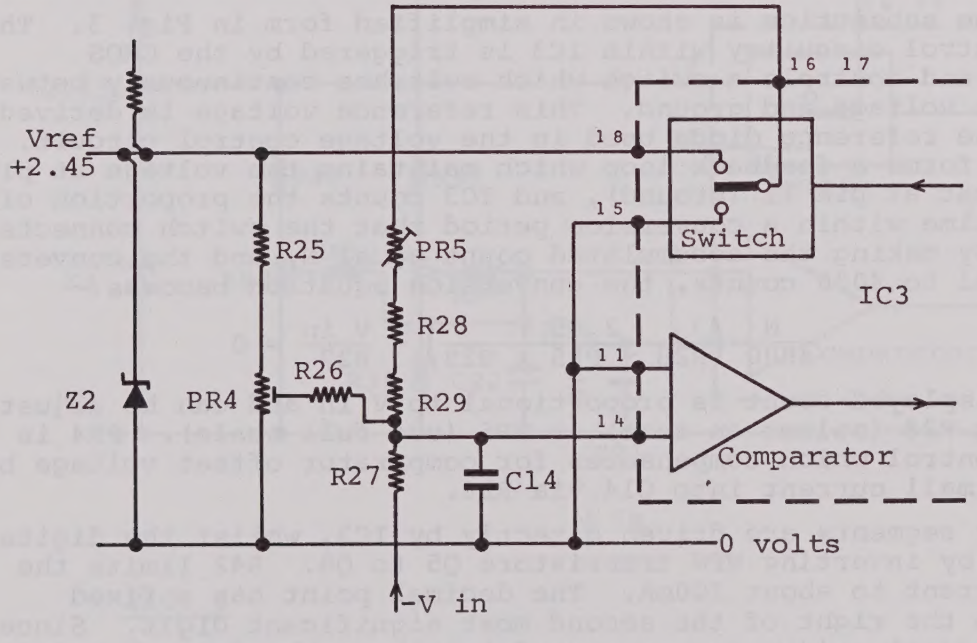

Vref
+2.45
R25
PR5
R28
Z2
PR4
R26
R29
R27
C14
16
17
18
15
Switch
IC3
11
14
Comparator
0 volts
-V in

FIG. 3

The common point of the supply is connected to the output of the main supply series regulator at point 11. This point is the zero volt reference point for the whole circuit.

The Voltage Control Circuit

The operation of the voltage stabilisation is most easily explained in conjunction with the simplified diagram Fig. 2. Voltage reference diode Z2 generates a highly stable voltage of 2.45 volts; this feeds current into the positive input of the op-amp, forcing the output up and allowing the series regulator to turn on and thus -V out to increase. It continues to increase until an equal current is being taken out via VR2 and VR3. Thus the circuit stabilises with -V out equal to $2.45 \times \left(\frac{VR2 + VR3}{PR1 + R11}\right)$ volts.

PR1 is set such that with VR2 + VR3 at maximum -V out = -31 volts.

Resistors R10 and R12 produce a small offset voltage that ensures that the output can always be brought down to zero. R13, D12 and D13 limit the maximum excursion at pin 3. D16 limits the maximum negative output excursion and C11 provides H.F. compensation.

The Voltmeter

The voltmeter is a $3\frac{3}{4}$ digit (4000 count) meter using a single CMOS IC (IC3) providing direct seven segment drive to a multiplexed 4 digi LED display DS1. It is unipolar, measuring voltages from 0 to -39.99 volts with a resolution of 10mV. IC3 is run between 0 and the V+ rail, C17 and C16 are decoupling electrolytics. The circuit operates at about 4 readings per second set by the clock components C15 and R3

The analogue subsection is shown in simplified form in Fig. 3. The digital control circuitry within IC3 is triggered by the CMOS comparator and controls a switch which switches continuously between a reference voltage and ground. This reference voltage is derived from Z2, the reference diode used in the voltage control circuit. The system forms a feedback loop which maintains the voltage at pin 1 equal to that at pin 11 (ground), and IC3 counts the proportion of the total time within a conversion period that the switch connects to Vref. By making the accumulated count equal N. and the conversion period equal to 4000 counts, the conversion equation becomes:-

$$\frac{N}{4000}\left(\frac{2.45}{R28 \times PR5 \times R29}\right) - \frac{V\ in}{R27} = 0$$

Thus the displayed count is proportional to V in and can be adjusted by altering R28 (select on test) or PR5 (set full scale). PR4 is a zero set control which compensates for comparator offset voltage by feeding a small current into C14 via R26.

The display segments are driven directly by IC3, whilst the digits are driven by inverting NPN transistors Q5 to Q8. R42 limits the display current to about 200mA. The decimal point has a fixed position to the right of the second most significant digit. Since all four decimal points are connected together, the decimal point drive has to be synchronised with the appropriate digit drive; this is done by Q9.

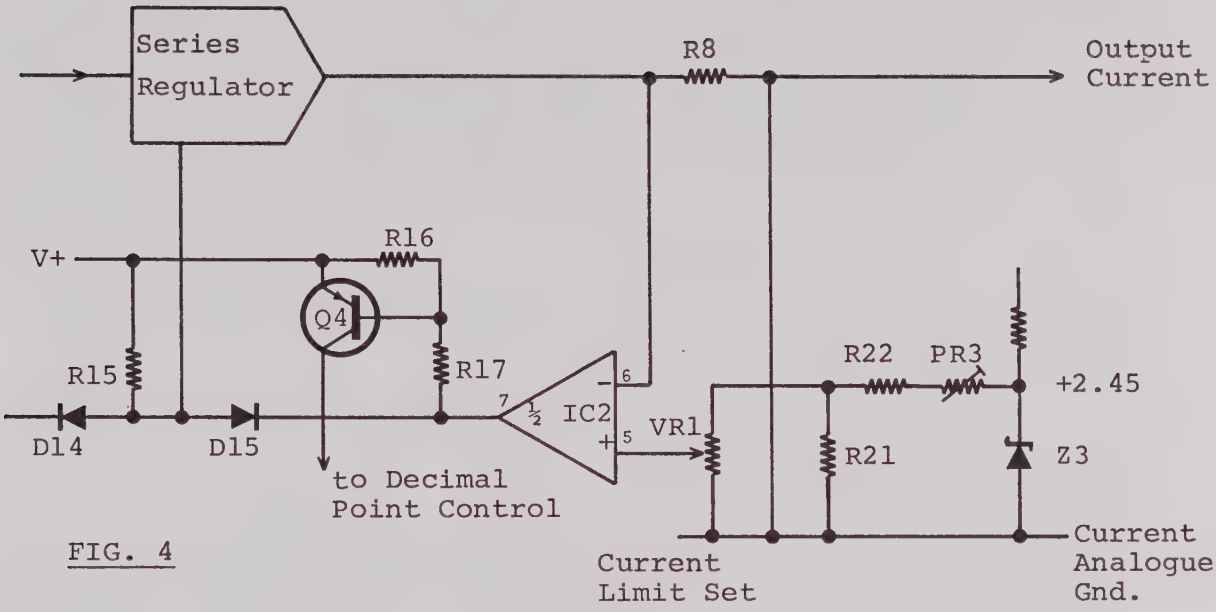

Series
Regulator
R8
Output
Current
V+
R16
Q4
R15
R17
D14
D15
IC2
VR1
R22
PR3
+2.45
R21
Z3
to Decimal
Point Control
Current
Limit Set
Current
Analogue
Gnd.

FIG. 4

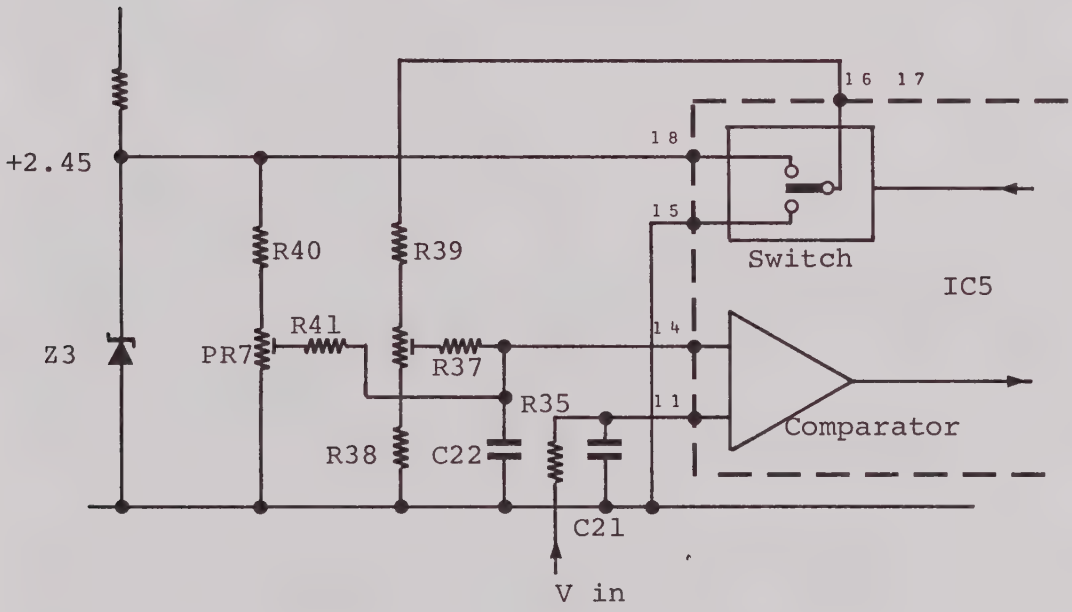

+2.45
R40
R39
Z3
PR7
R41
R37
R35
R38
C22
C21
V in
Switch
IC5
Comparator

FIG. 5

The Current Control Circuit

The operation of the current stabilisation circuit is most easily explained in conjunction with the simplified diagram Fig. 4. Referenc diode Z3 provides a highly stable voltage of +2.45 volts above the Current Analogue ground (this is normally equal to 0 volts but can be higher if remote sense is being used). This voltage is potted down by PR3, R22 and R21, and applied to the positive input of the op-amp via the current control VR1. This voltage forces the op-amp output positive allowing the Series Regulator to be controlled by the Voltage Control Circuit until the output current flowing in R8 reaches a point where an equal voltage appears on the negative input, upon which the output falls turning off the series regulator and maintaining a consta current equal to $\frac{\text{V in (pin 5)}}{\text{R8}}$.

When this occurs, Q4 turns on providing a signal to the current meter decimal point control circuit.

R18, R19 and PR2 provide an offset voltage null control. R20 provides a balanced source impedance, and R50 and C26 provide H.F. compensation

Current Meter

The Current Meter is a $3\frac{3}{4}$ digit (4000 count) meter using a single CMOS IC (IC5) providing direct segment drive to a multiplexed 4 digit LED display DS2. It is unipolar, measuring voltages between 0 and +2 volts with a resolution of 0.5mV. This is converted to a resolution of 1mA by measuring across the 0.5Ω resistor R8. IC5 is run between 0 and the V+ rail, C18 and C19 are decoupling electrolytics. The circuit operates at about 4 readings per second set by the clock components R36 and C20.

The analogue subsection is shown in simplified form in Fig. 5. The digital control circuitry within IC5 is triggered by the CMOS comparator and controls a switch which switches continuously between a reference voltage and ground. This reference voltage is derived from Z3, the reference diode used in the current control circuit. It is reduced by the potential divider R38, PR6 and R38 to produce Vref equal to 2 volts. The system forms a feedback loop which maintains the voltage at pin 14 equal to that at pin 11 (V in), and IC5 counts the proportion of the total time within a conversion period that the switch connects to the reference voltage. By making the accumulated count equal N and the conversion period equal to 4000 counts, the conversion equation becomes:-

$$\frac{N}{4000} \times \text{Vref} = \text{V in} \quad \text{or} \quad N = 4000 \frac{\text{V in}}{\text{Vref}}$$

where $$\text{Vref} = \text{VZ3} \times \frac{\text{R38}}{\text{R38 + R39}} \quad \text{(ignoring PR6)}$$

thus the displayed count is proportional to V in and can be adjusted by altering R39 (select on test) or PR6 (set full scale).

PR7 is a zero set control which compensates for comparator offset voltage by feeding a small current into R37 via R41. R37, C22 and R23, C21 filter the inputs to the comparator.

The display segments are driven directly by IC5 whilst the digits are driven by inverting NPN transistors Q11 to Q14. R48 limits the displ current to about 200mA.

Meter Select Circuit

The voltage applied to the current meter can be either the voltage generated across R8 or the voltage on the slider of VR1. This is selected by IC4 which contains an inverter and two analogue switches. The control signal for IC4 comes from Q15 which is driven on or off by the position of the DC output switch S2 via R31. Q15 also provides an output to the decimal point control circuit. With S2 'off', Q15 is on and IC4 connects the current meter to VR1 to read the current limit setting.

Damping Switch

The voltage generated across R8 is applied to C24 via the damping switch S3. When this switch is 'off', the contacts are closed and C24 has no effect, but when S3 is 'on' the contacts open and the voltage is applied to C24 via R49 producing a long time constant.

Decimal Point Control Circuit

The Current Meter decimal points are driven by IC6 via the emitter follower Q10. With the DC output switch S2 'off' a signal from Q15 turns the decimal points permanently on. With S2 'on' the decimal points turn off unless Q4 is turned on by the current control circuit operating. This causes IC6 to operate as a monostable triggered by the 'conversion complete' signal from pin 8 of IC5, and with a time constant defined by C23 and R46. This results in flashing decimal points.

Quad-Mode Dual Link Unit

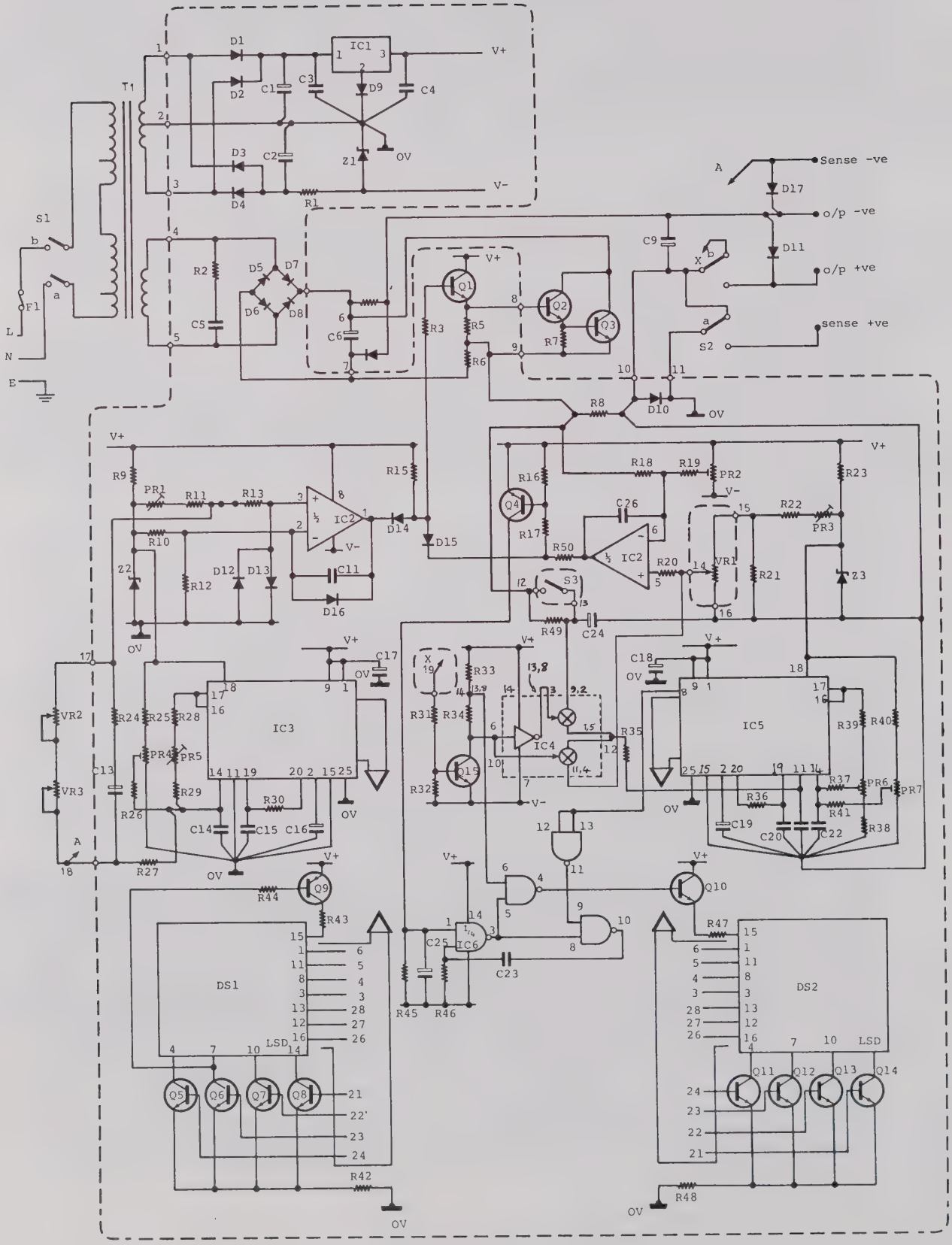
The Link Unit incorporates a bank of four switches which allow four modes of operation of be obtained.

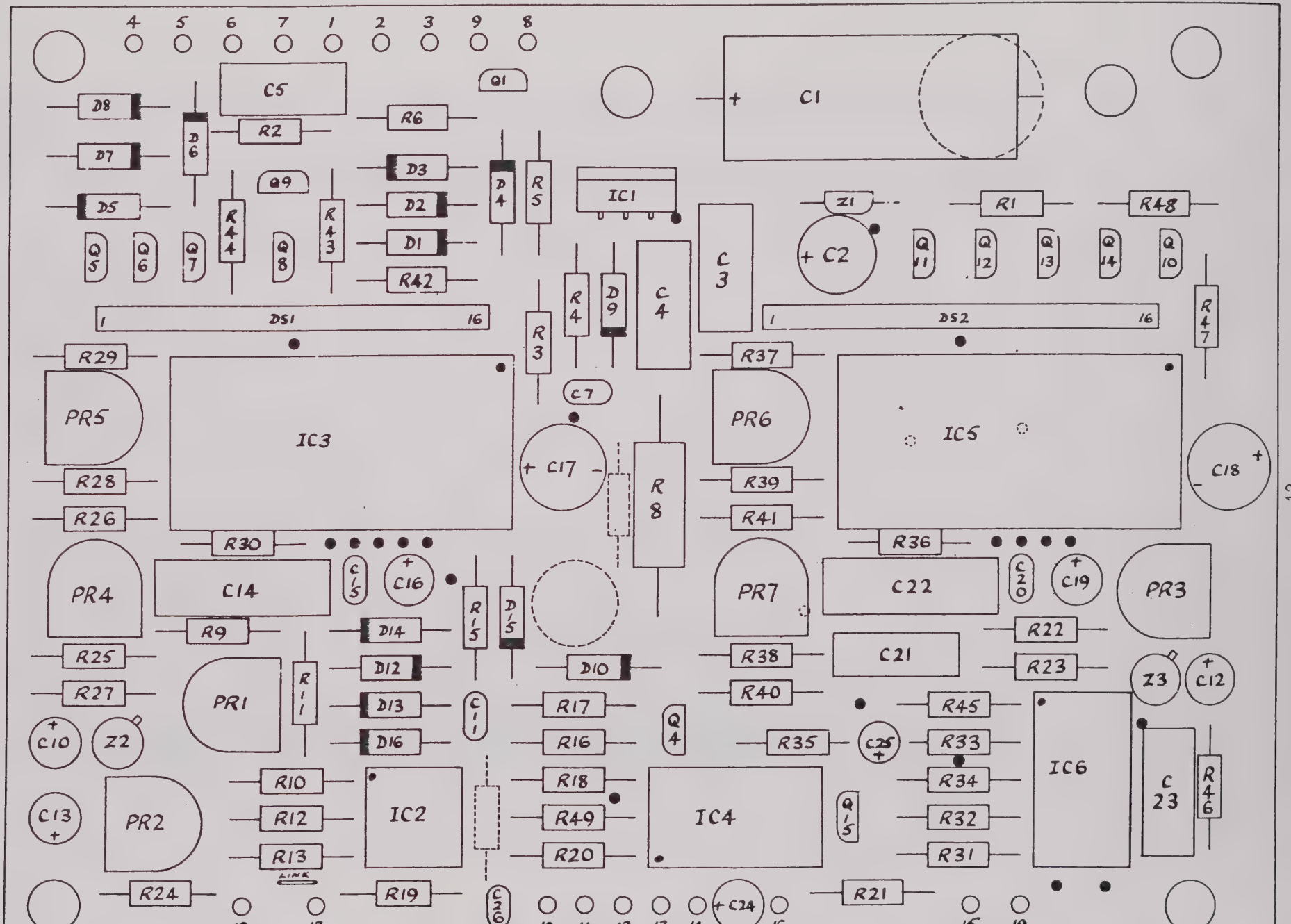
Isolated: SW1 (Release) depressed. All interconnection between the two units is removed.

Parallel: SW2 depressed. The Slave unit pass transistors are driven from Q1 on the Master PCB, and their output is combined with that of the Master unit, thus doubling its current capability. VR1 on the Master unit is disconnected from the junction of R21 and R22 and connected to a network generating twice the control voltage. The Slave unit becomes inoperative.

Series: SW3 depressed. The Slave unit positive terminal is connected to the Master unit negative terminal.

Tracking: SW4 depressed. As for Series, but additionally the +ve input to the Slave unit voltage control op-amp is disconnected from the junction of VR2 and R11 and is instead connected to a potential divider connected between Master unit +ve output and Slave unit -ve output. This maintains the voltage at the Slave +ve output (and hence the Master -ve output) equal to ½ of the total output voltage, thus producing tracking supplies of ±30V controlled from VR2 and VR3 on the Master unit. VR2 and VR3 on the Slave unit become inoperative.


T1
S1
F1
L
N
E
D1
D2
D3
D4
C1
C2
C3
C4
C5
C6
R1
R2
D5
D6
D7
D8
D9
Z1
IC1
V+
V-
OV
A
Sense -ve
D17
o/p -ve
D11
o/p +ve
sense +ve
S2
C9
X
b
a
Q1
Q2
Q3
R3
R5
R6
R7
R8
D10
R9
PR1
R11
R13
R10
R12
D12
D13
Z2
IC2
D14
D15
R15
C11
D16
R16
Q4
R17
R18
R19
PR2
R23
C26
R22
PR3
R50
R20
VR1
R21
Z3
S3
R49
C24
C17
IC3
VR2
VR3
R24
R25
R28
PR4
PR5
R29
R30
R26
C13
C14
C15
C16
R27
R44
Q9
R43
DS1
LSD
Q5
Q6
Q7
Q8
R42
R33
R34
R31
R32
Q15
IC4
R35
C25
IC6
C23
R45
R46
C18
IC5
R39
R40
R37
PR6
PR7
R36
R41
C19
C20
C22
R38
Q10
R47
DS2
Q11
Q12
Q13
Q14
R48


4 5 6 7 1 2 3 9 8
C5
Q1
C1
D8
D7
D6
R2
R6
D5
Q9
D3
D2
D1
R42
D4
R5
IC1
Z1
R1
R48
Q5
Q6
Q7
R44
Q8
R43
+ C2
Q11
Q12
Q13
Q14
Q10
C 3
DS1
1
16
DS2
R47
R3
R4
D9
C 4
R29
R37
PR5
IC3
C7
PR6
IC5
C18
+ C17 -
R 8
R28
R39
R26
R41
R30
R36
PR4
C14
C 15
+ C16
R 15
D 5
PR7
C22
C 20
+ C19
PR3
R9
D14
R22
R25
D12
R38
C21
R23
R27
PR1
R 11
D13
C 11
R17
Q 4
R40
R45
Z3
+ C12
+ C10
Z2
D16
R16
R35
+ C25
R33
IC6
R10
R18
R34
C 23
R46
C13 +
PR2
R12
IC2
R49
IC4
Q 15
R32
R24
R13
LINK
R20
R31
R19
C 26
+ C24
R21

PARTS LIST

Resistors - 5% CF ¼ Watt, unless otherwise stated.

R1 - 1KΩ
R2 - 470Ω
R3 - 100Ω
R5 - 1KΩ
R6 - 2K2 0.5 watt
*R7 - 100Ω
R8 - 0.5Ω WW 5% 5 watt
R9 - 1KΩ
R10 - 820KΩ
R11 - 3K6 MF 1%
R12 - 3K3
R13 - 3K3
R15 - 1K8
R16 - 10K
R17 - 22K
R18 - 10K
R19 - 10M (10%)
R20 - 10K
*R21 - 1K 2%
R22 - 2K7 2%
R23 - 1K
R24 - 100Ω
R25 - 560K
R26 - 10M (10%)
R27 - 2M7 MF 1%
R28 - SOT
R29 - 150K MF 1%
R30 - 12K
R31 - 220K
R32 - 100K
R33 - 100K
R34 - 100K
R35 - 100K
R36 - 12K
R37 - 100K
R38 - 100K 2%
R39 - SOT
R40 - 220K
R41 - 10M (10%)
R42 - 10Ω 0.5 watt
R43 - 47Ω
R44 - 1K
R45 - 220KΩ
R46 - 2M2
R47 - 10Ω
R48 - 10Ω 0.5 watts
R49 - 100K
R50 - 470Ω

Preset Resistors

PR1 - 1K 10mm Carbon
PR2 - 100K " "
PR3 - 1K " "
PR4 - 100K " "
PR5 - 4K7 " Cermet
PR6 - 4K7 " Cermet
PR7 - 100K " Carbon

Variable Resistors

VR1 - 10K Log Plessey PR16
VR2 - 50K Lin Colvern 4001/11S
VR3 - 1K Lin Radiohm R26

Capacitors

C1 - 1000µF/16V Elec.
C2 - 47µF/16V Elec.
C3 - 0.1 Polyester
C4 - 0.1 Polyester
C5 - .1µ Polyester
*C6 - 2200µF/63V Elec.
C9 - 33µ 100V Elec.
C11 - 47pF Ceramic
C13 - 1µ 100V Elec.
C14 - .22µF Polyester
C15 - 100pF Ceramic
C16 - 10µF/16V Elec.
C17 - 220µF/10V Elec.
C18 - 220µF/10V Elec.
C19 - 10µF/16V Elec.
C20 - 100pF Ceramic
C21 - 0.22µF Polyester
C22 - 0.22µF Polyester
C23 - 0.1µF Polyester
C24 - 10µF/16V Elec.
C25 - 2.2µF/63V Elec.
C26 - 47pF Ceramic

/continued...

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*R7 - 47Ω (PL320)
R21 - 3K3 (PL320)

*C6 - 2 x 2200µF/63V (PL320)

PARTS LIST (Contd...)

Diodes

D1 - IN4003
D2 - IN4003
D3 - IN4148
D4 - IN4148
*D5 - IN4003
*D6 - IN4003
*D7 - IN4003
*D8 - IN4003
D9 - IN4148
D10 - IN4003
D11 - IN4003
D12 - IN4148
D13 - IN4148
D14 - IN4148
D15 - IN4148
D16 - IN4148
D17 - IN4003

Zener Diodes

Z1 - BZV41C5V6
Z2 - ZN404T
Z3 - ZN404T

Transistors

Q1 - ZTX450
*Q2 - 2N3055H
*Q3 - 2N3055H
Q4 - ZTX214
Q5 - ZTX450
Q6 - ZTX450
Q7 - ZTX450
Q8 - ZTX450
Q9 - ZTX214
Q10 - ZTX450
Q11 - ZTX450
Q12 - ZTX450
Q13 - ZTX450
Q14 - ZTX450
Q15 - ZTX450

Integrated Circuits

IC1 - MC7805CT
IC2 - LM358N
IC3 - ADD3701CCN
IC4 - CD4007AE
IC5 - ADD3701CCN
IC6 - CD4011AE

L.E.Ds

DS1 - NSB5881
DS2 - NSB5881

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*D5 to D8 - IN5401 (PL320)

*Q2 - TIP31A (PL320)
Q3 - 4 x 2N3055H (PL320)

CALIBRATION PROCEDURE

Re-calibration to original specification requires only the following equipment:-

(i) A 4½ digit voltmeter of accuracy ≤0.05% reading ± 1 digit on the 200V range.

(ii) A 3½ digit current meter of accuracy ≤0.1% reading ± 1 digit on the 2A range,

or

(iii) a resistor of value known to ≤0.05% at 1 amp in conjunction with (i).

The unit may be re-calibrated to a lower specification using less precise equipment.

Procedure is as follows:- .

(a) Connect voltmeter to output. Turn VR2 to minimum. Adjust VR3 for an output voltage of 0.02 volts. Adjust PR4 for PL meter reading of 0.02V.

(b) Turn VR2 and VR3 to maximum. Adjust PR5 for PL meter voltage reading exactly equal to V out.

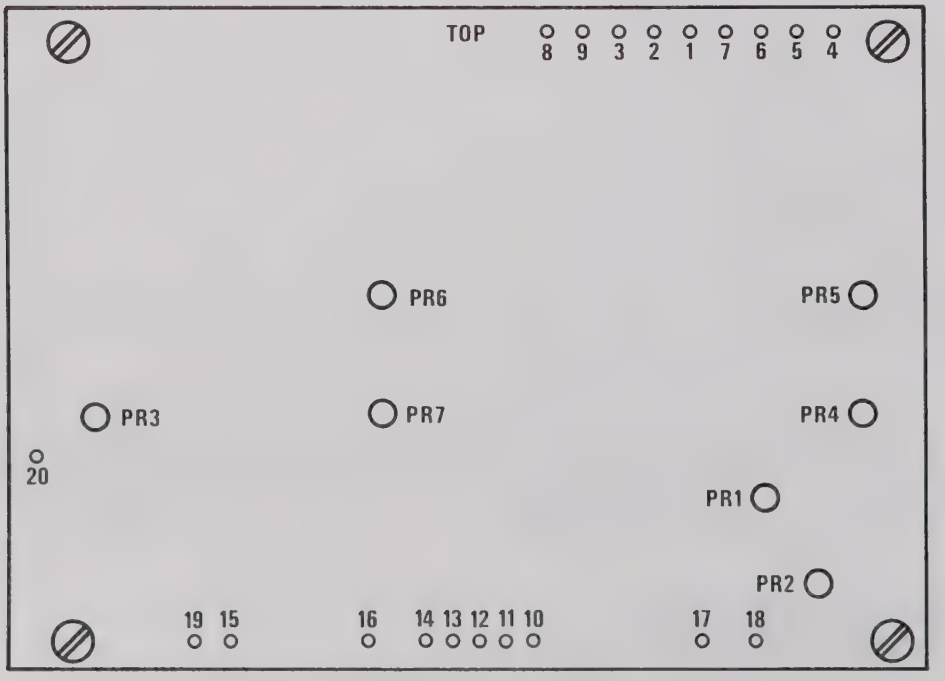
(c) Adjust PR1 for V out = 31.00 ± 10 digits.

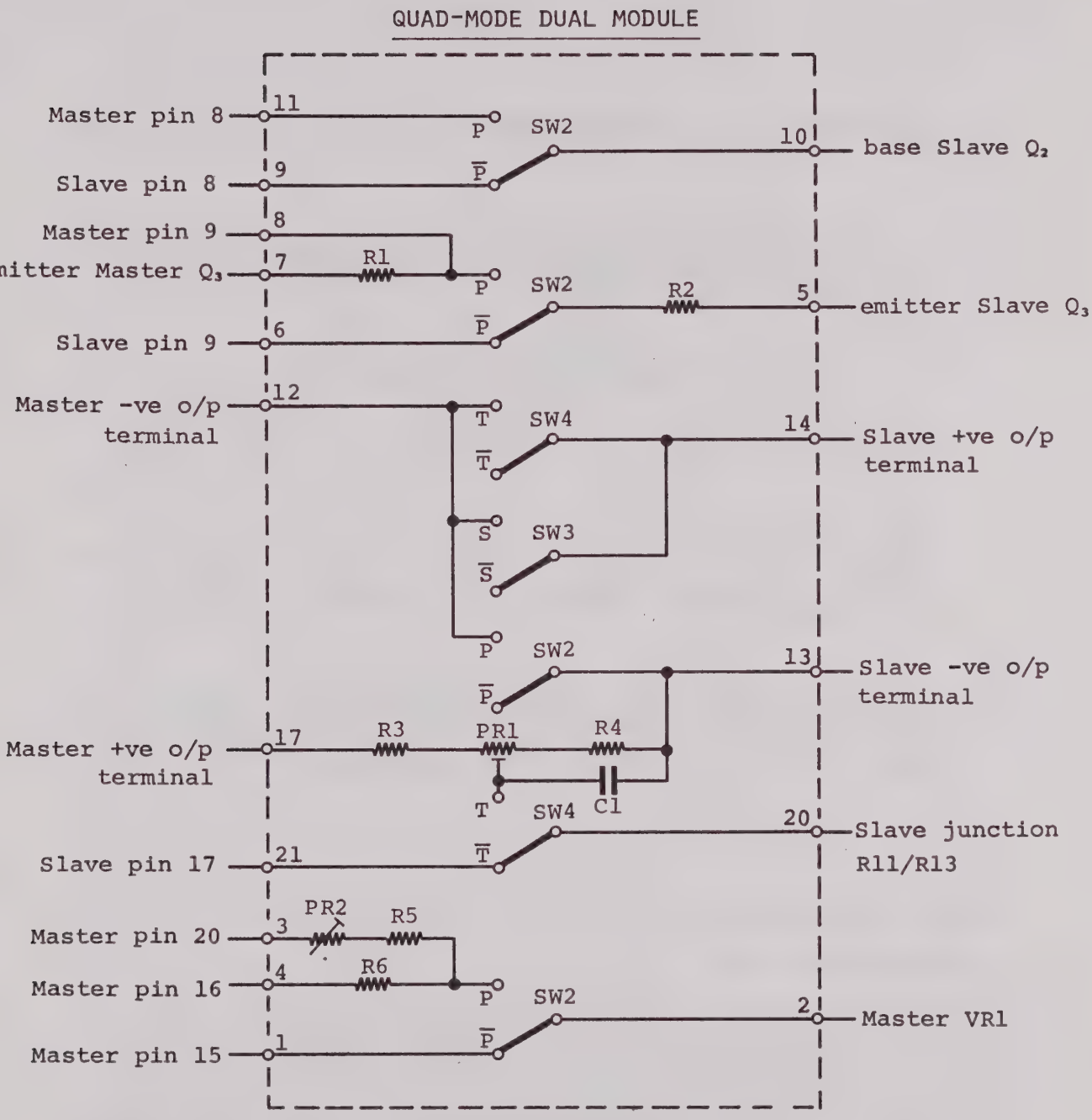
(d) Connect a 15kΩ ± 5% resistor across the output. Adjust PR7 for PL meter reading of 002mA.

(e) Connect current meter or shunt resistor across the output. Set VR1 for 1 amp output current. Adjust PR6 for PL current reading exactly equal to I out.

(f) Disconnect Load. Set VR1 to maximum. Adjust PR3 for current limit setting of 1100 ± 5 digits (PL310) or 2200 ± 10 digits (PL320).

(g) Set VR2 and VR3 to maximum. Set VR1 to minimum. Adjust PR2 such that output voltage collapses to about 10 volts.





Pin numbering on Quad-Mode PCB starts from 1 at the top

Quad-Mode Dual Calibration

PR1 (mounted at the bottom of the PCB) adjusts the tracking accuracy when in tracking mode. Set Master to 30 volts, switch both DC output switches on. select Tracking mode and adjust PR1 for equal readings on the two voltmeters.

PR2 (mounted at the top of the PCB) adjusts the max. current limit setting when in parallel mode. Set Master current limit to maximum, switch both DC output switches off, select Parallel mode, and adjust PR2 for a reading of 2200 ± 10 (PL310 Dual) or 3980 ± 20 (PL320 Dual) on the Master current meter.

K MODULE - INTRODUCTION

The PL310K and PL320K are triple output supplies which consist of a standard PL310 or PL320 linked with a K1 or K2 module respectively.

The K module incorporates two separate outputs, a fully variable 0 to 30 volt output and a high current 4 to 6 volt output with overvoltage crowbar and remote sense. Both supplies are isolated and floating.

The 30 volt supply has no metering and a fixed current limit of 0.55A (K1) or 1.1A (K2). A switch enables the output either to be set independently via a calibrated knob, or to become a series tracking slave to the PL310/320.

The 5 volt supply has a digital current meter and a fixed current limit of 3.65 amps (K1) or 7.3 amps (K2) with a foldback characteristic. A user adjustable dual speed overvoltage crowbar is incorporated.

CIRCUIT DESCRIPTION

5 volt section

All the supplies for this section are generated by a single 11 volt winding. The main supply is from bridge rectifier BR1 into reservoir capacitor C3. Diodes D1 and D2 provide an equal positive supply which is not loaded by the output. D1, D3, D4, C4 form a voltage doubler which is stabilised to -5.6 volts by Z1. A stabilised rail of +5.7 volts is generated by IC1 and D6 from the main supply.

The series regulator TR9, TR10, TR11 is placed in the positive side of the mains supply, and is driven by TR8 from R39.

Voltage control amplifier IC2a sets the output voltage equal to $\frac{R32 + R28}{R28}$ times the voltage on the slider of VR1. This voltage is derived from the reference diode Z3. IC2c is a ground line buffer which keeps the negative sense terminal high impedance.

When the output current exceeds the level set by PR2 to be approximately $\frac{R16}{R15 + R16} \times \frac{2.45}{R17}$, the current control amplifier IC2b takes over control of the series regulator via D8. TR7 provides a foldback characteristic to the current limit if the output voltage falls below 4 volts.

When pin 1 of IC2b goes low, TR6 turns on, causing the Astable Oscillator TR1, TR2 to flash the current meter decimal points via TR5.

IC2d senses the output voltage via PR5, and if it exceeds the preset theshold, turns on thyristor TH1 via D9. The operation of this circuit is delayed by C9 to avoid triggering by transient spikes. If the ouput approaches 10 volts, however, TR1 is turned on instantaneously Via Z4. When TH1 is on, TR4 is turned on, causing permanent illumination of the current meter decimal points via TR5 to indicate that the output has been crowbarred. The supply must be turned off, or the output short circuited to reset this circuit.

The output current flowing through R17 is measured, and displayed by IC3. The operation of this circuit is identical to that for the PL310/320 current meter.

30 Volt Section

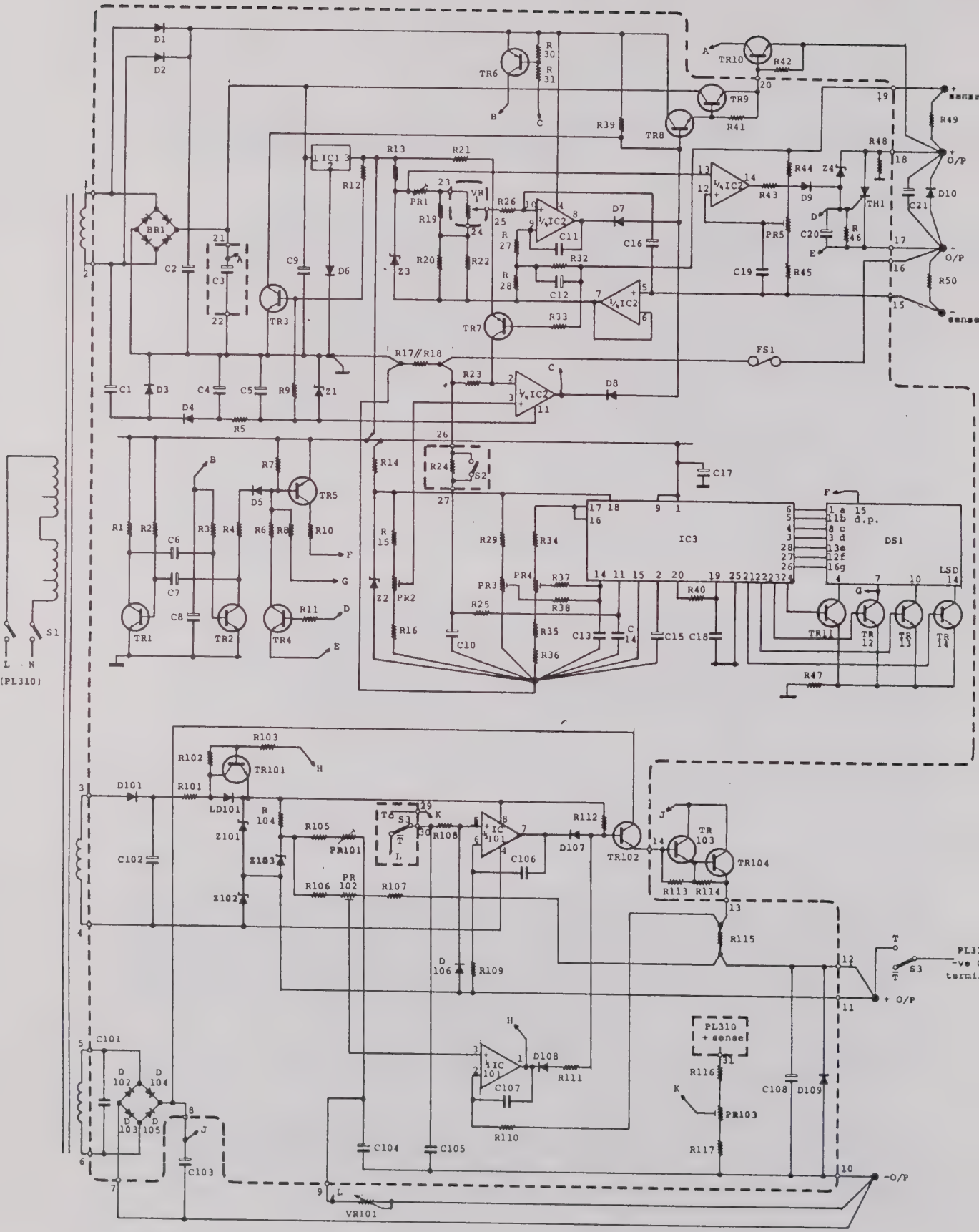
The operation of this section is very similar to the standard PL310/320 supply.

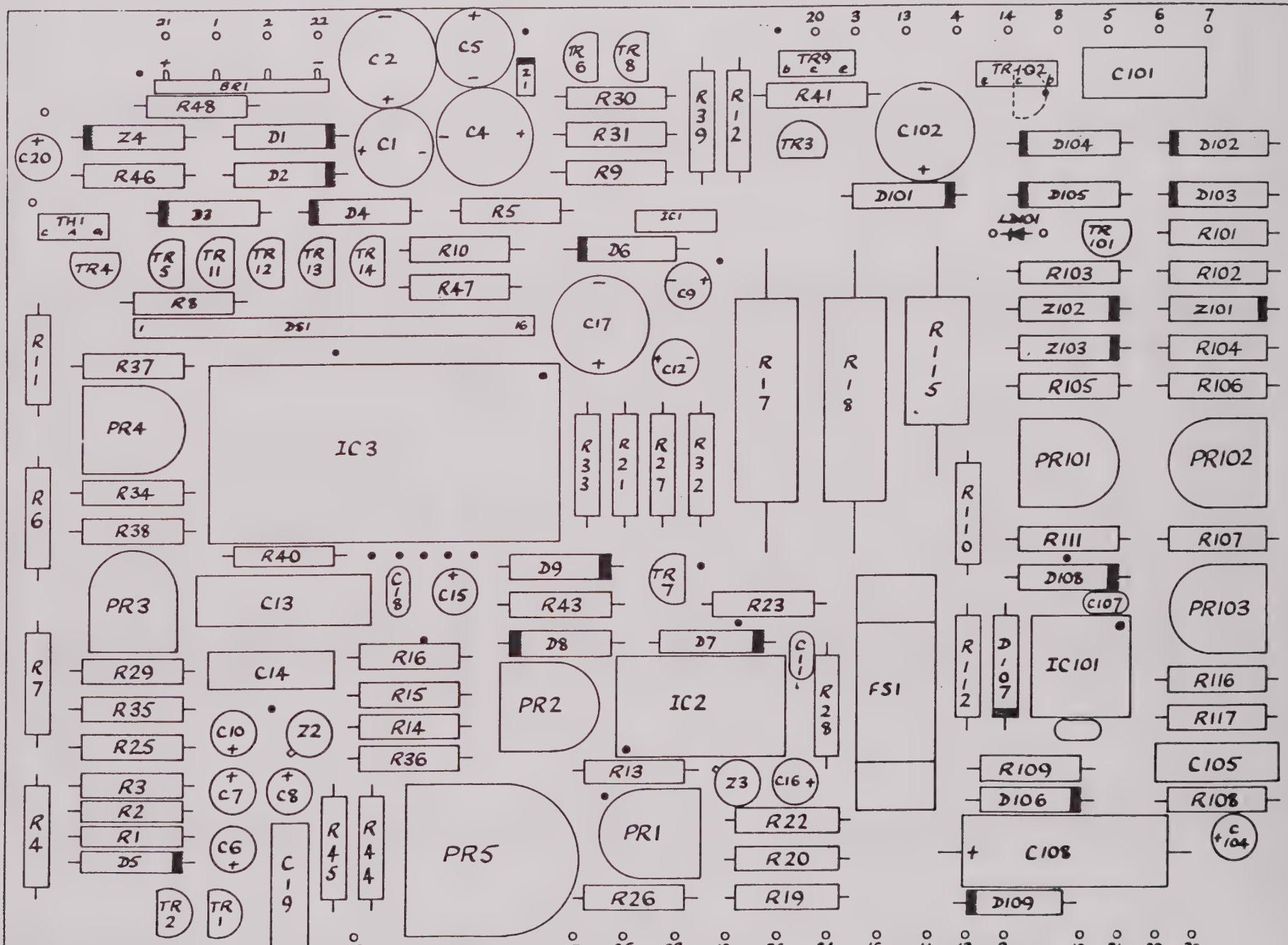
The main supply is generated by a 36 volt winding into bridge rectifier D102 to 105 and reservoir capacitor C103. The Series regulator TR102 to TR104 is placed in the positive side.

The auxilliary supply is generated by a 36 volt winding into D101 and C102 and is split into +10 volts and -5.6 volts by zener diodes Z101 and Z102. The centre point of this supply is connected to the output positve terminal. Diode Z103 provides a reference voltage both for the voltage control amplifier IC101a and the current control amplifier IC101b.

In 'Isolated' mode the wire-wound variable resistor VR101 sets the output voltage equal to $5V6 \times \frac{VR101}{R105 + RR101}$ and controls the output via D107. In'Tracking' mode, the positive input of IC101a is disconnected from VR101 and connected to the slider of PR103. At the same time the positive output terminal becomes linked to the negative output terminal of the PL310/320 supply. Since R116 and R117 are equal, this causes the output voltage to become equal to that set on the 'master' supply.

When the output current exceeds the level set by PR102 to be approximately $\frac{R107}{R106 \times R107} \times \frac{5V6}{R115}$, IC101b controls the output via D108. Thus, the supply switches automatically into constant current mode. As pin 1 of IC101b goes low, it turns off TR101 and allows the LED LD101 to come on, thus indicating an overload condition.


D1
D2
BR1
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
C18
C19
C20
C21
D3
D4
D5
D6
D7
D8
D9
D10
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17//R18
R19
R20
R21
R22
R23
R24
R25
R26
R27
R28
R29
R30
R31
R32
R33
R34
R35
R36
R37
R38
R39
R40
R41
R42
R43
R44
R45
R46
R47
R48
R49
R50
TR1
TR2
TR3
TR4
TR5
TR6
TR7
TR8
TR9
TR10
TR11
TR12
TR13
TR14
IC1
IC2
IC3
DS1
TH1
Z1
Z2
Z3
PR1
PR2
PR3
PR4
PR5
VR
S1
S2
FS1
L
N
(PL310)
+ sense
+ O/P
- O/P
- sense
LSD
d.p.
TR101
TR102
TR103
TR104
D101
D102
D103
D104
D105
D106
D107
D108
D109
LD101
Z101
Z102
Z103
R101
R102
R103
R104
R105
R106
R107
R108
R109
R110
R111
R112
R113
R114
R115
R116
R117
PR101
PR102
PR103
IC101
C101
C102
C103
C104
C105
C106
C107
C108
T6
S3
VR101
PL310
+ sense
+ O/P
-O/P
-ve
termi.


21 1 2 22
BR1
C2
C5
C1
C4
C20
Z1
TR6
TR8
R30
R31
R9
R39
R12
TR9
R41
TR3
C102
TR102
C101
20 3 13 4 14 8 5 6 7
R48
Z4
D1
R46
D2
D101
D104
D102
D105
D103
LED1
TR101
R101
R103
R102
Z102
Z101
Z103
R104
R105
R106
TH1
TR4
TR5
TR11
TR12
TR13
TR14
R10
R47
R8
DS1
IC1
D6
C9
C17
C12
R11
R37
PR4
IC3
R34
R38
R6
R33
R21
R27
R32
R17
R18
R15
R110
PR101
PR102
R111
R107
D108
C107
PR103
R40
D9
R43
TR7
R23
C13
C18
C15
PR3
R7
R29
R35
R25
C14
R16
R15
R14
R36
D8
D7
PR2
IC2
C11
R28
FS1
R112
D107
IC101
R116
R117
C10
Z2
R13
Z3
C16
C105
R109
D106
R108
R3
R2
R1
D5
R4
C7
C8
C6
C19
R45
R44
PR5
PR1
R22
R20
R19
R26
C108
C104
D109
TR2
TR1

K1 MODULE PARTS LIST

All resistors 1/4W 5% Carbon Film unless otherwise stated.

	K1	K2 if different
R1	3K3	
R2	150K	
R3	560K	
R4	3K3	
R5	330R	
R6	3K3	
R7	3K3	
R8	Not used	3K3
R9	5K6	
R10	47R	
R11	10K	
R12	10K	
R13	680R	
R14	680R	
R15	3K0 2%	
R16	3K0 2%	
R17	0.68R W/W	Not used
R18	0.68R W/W	0.034Ω Laminar
R19	1K0 1% M.F.	
R20	2K0 1% M.F.	
R21	47K	
R22	100K	
R23	10K	1K8
R24	100K	
R25	100K	
R26	10K	
R27	5K6	
R28	11K0 1% M.F.	
R29	1M	
R30	3K3	
R31	1K8	
R32	18K 1% M.F.	
R33	100K	
R34	68K 1% M.F.	
R35	S.O.T.	
R36	62K 1% M.F.	
R37	150K	
R38	10M	
R39	4K7	
R40	12K	
R41	1K	
R42	47R	
R43	680R	
R44	220K	
R45	120K	
R46	3K3	
R47	10R ½W	
R48	100R ½W	
R49	470R	
R50	470R	
R51	Not used	220K
R52	Not used	0R22 W/W
R53	100K	
R54	Not used	
R55		

/contd...

	K1	K2
R101	680R	
R102	2K7	
R103	4K7	
R104	1K	
R105	6K8 1% M.F.	
R106	47K	56K
R107	2K0	
R108	3K3	
R109	5K6	
R110	10K	
R111	470R	
R112	1K8	
R113	Not used	47R
R114	47R	1.2R ½W M.F.
R115	0.47R M.F.	0.22R ½W M.F.
R116	470K 2%	
R117	470K 2%	
R118	12K (not fitted as standard)	
PR1	500R 10mm carbon	
PR2	1K " "	
PR3	100K " "	
PR4	5K " cermet	
PR5	100K 15mm carbon	
PR101	5K 10mm carbon	
PR102	1K " "	
PR103	25K " "	
VR1	50K lin. Colvern W/W	
VR101	50K lin. Colvern W/W	
C1	47µF 25V Electrolytic	
C2	100µF 25V "	
C3	10,000µF 25V "	
C4	220µF 16V "	
C5	47µF 10V "	
C6	1µF 63V "	
C7	1µF 63V "	
C8	2µ2 63V "	
C9	1µF 63V "	
C10	10µF 16V "	
C11	1nF Ceramic	
C12	1µF 63C Electrolytic	
C13	0.22µF Polyester	
C14	0.1µF Polyester	
C15	10µF 16V Electrolytic	
C16	1µF 63V "	
C17	220UF 10V "	
C18	100pF Ceramic	
C19	0.1µF Polyester	
C20	1µF 63V Electrolytic	
C21	100µF 25V "	
C22	Not used	10,000µF 25V

/contd...

	K1	K2
C101	0.1µF Polyester	
C102	100µF 40V Electrolytic	
C103	1000µF 63V "	2200µF 63V
C104	2µ2 63V "	
C105	0.22µF Polyester	
C106	Not used	
C107	47pF Ceramic	
C108	33µF 63V Electrolytic	
TH1	C122B1 or C126B1	
BR1	KBL01 or KBL02	26MB5A
IC1	LM340-T-5	
IC2	LM324	
IC3	ADD3701	
IC101	LM358	
DS1	NSB5881	
LD101	NSL5053	
TR1	ZTX239	
TR2	"	
TR3	"	
TR4	"	
TR5	ZTX214	
TR6	"	
TR7	"	
TR8	ZTX450	
TR9	TIP31A	
TR10	2N3055H	
TR11	ZTX450	
TR12	"	
TR13	"	
TR14	"	
TR15	Not used	2N3055H
TR101	ZTX239	
TR102	TIP31A	
TR103	Not used	2N3055H
TR104	2N3055H	
Z1	5V6	
Z2	ZN404T	
Z3	ZN404T	
Z4	10V	
Z101	10V	
Z102	5V6	
Z103	5V6	

/contd...

	K1	K2
D1	1N4003	
D2	"	
D3	"	
D4	"	
D5	1S44	
D6	"	
D7	"	
D8	"	
D9	"	
D10	1N4003	1N5401
D101	1N4003	
D102	"	
D103	"	
D104	"	
D105	"	
D106	1S44	
D107	"	
D108	"	
D109	1N4003	